VOL. XVIII, No. 13 BULLETIN 1923
OF THE
OHIO STATE UNIVERSITY AGRICULTURAL COLLEGE EXTENSION SERVICE
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Eradication of Common Barberry and Black Stem Rust in Ohio

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THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO, AND THE UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

FREE—Cooperative Agricultural Extension Work—Acts of May 8 and June 30, 1914

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Damage Due to Black Stem Rust.—Black stem rust, caused by *Puccinia graminis*, is among the most destructive of fungous diseases of plants. The parasite attacks wheat, oats, barley, rye, and many wild grasses. It is prevalent wherever these crops are grown. Resulting damage is in the nature of ruined crops not harvested, reduced yields, and grain of low weight and poor quality. Altho the severity of the disease varies in different seasons, black stem rust destroys many millions of bushels of small grain annually. It has been estimated that, in 1916, black stem rust caused a loss of more than 200,000,000 bushels of wheat in the United States. According to estimates of the United States Department of Agriculture, stem rust reduced the wheat yield in Ohio by a total of 3,634,000 bushels during the seasons of 1918, 1919, 1921 and 1922. Only a trace of rust was reported in 1920.

While Ohio is not visited by statewide epidemics, as are some of the western states growing spring wheat, stem rust occurs every year, usually in the form of severe local epidemics. It is difficult to estimate the losses under these conditions. Such losses are not divided proportionally among all the wheat growers of the state, but fall heavily upon the farmers in certain communities. Individual farmers have reported losses as high as $2,000, and in many communities the ravages of this disease have compelled the farmers to stop trying to grow wheat.

How to Distinguish Between Stem Rust and Leaf Rust.—Rust is caused by a parasitic fungus, which is a plant that lives on and obtains nourishment from other plants. The black stem rust fungus propagates by the production of spores which serve as seeds. Rust is not caused by hot, wet weather, altho such climatic conditions are favorable for rapid spore production and germination, and thus for the spread of the disease. It should be emphasized that two kinds of rust occur on grain in Ohio, namely: leaf rust and stem rust. Both kinds develop a summer stage and a winter stage. In the summer stage the spores and spore pustules

The cuts for figures 1-4, inclusive, were furnished by the United States Department of Agriculture

are red, and in the winter stage they are black. In Ohio, the summer, or red stage of the leaf rust usually appears on wheat in abundance in April; while the summer, or red stage of stem rust

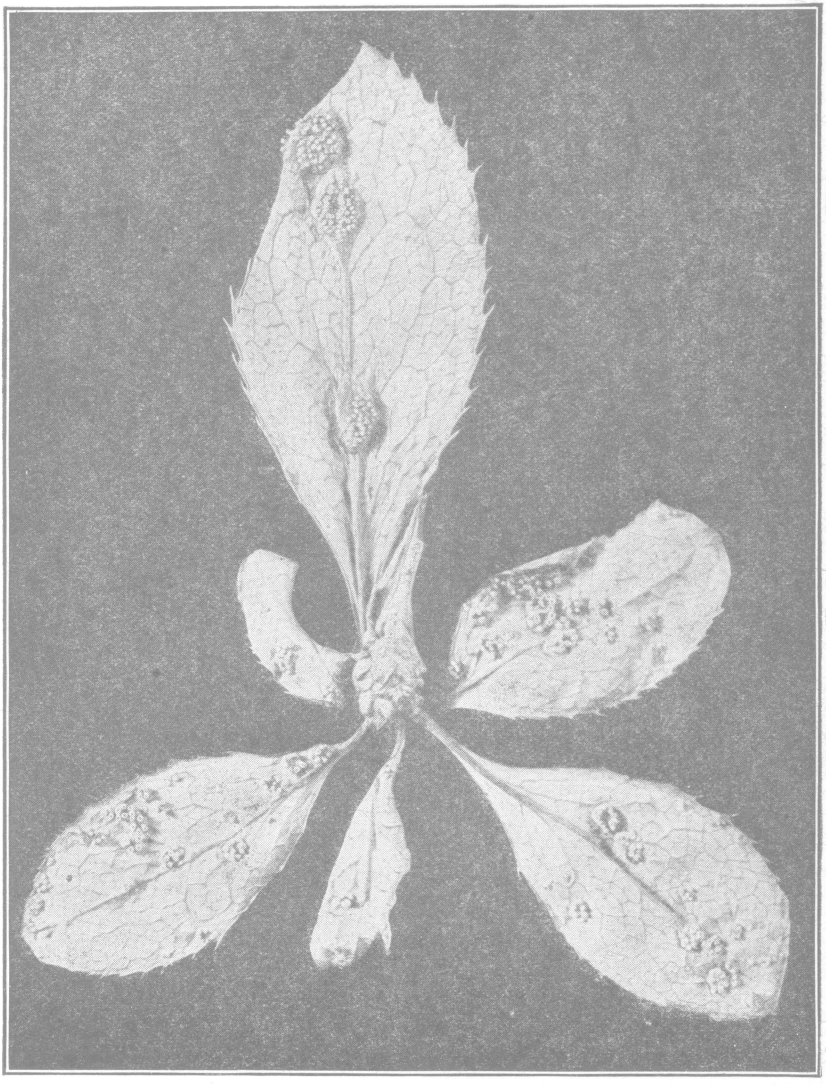

Fig. 1.—Infected common barberry leaves, showing the cluster-cup-stage of the rust.

starts early in May. Leaf rust is generally confined to the leaf blades, while stem rust is most abundant on the leaf sheaths and stems of grain plants. Leaf rust has no connection with the com-

mon barberry and will not be discussed further. Stem rust has a very definite relation to the barberry.

Life Story of the Black Stem Rust.—The stem rust fungus lives a double life. It spends a part of its existence on grain and a part on the leaves of the common barberry as shown in Fig. 1. In

Fig. 2.—A common barberry bush, showing its tall, erect growth

early spring, clusters of small cups *(aecia)* containing numerous yellow spores *(aeciospores)* develop on the lower side of common barberry leaves. These yellow spores are blown by the wind to grain plants. Here they germinate, and infection of the grain results. In a short time elongated rust pustules *(uredinia)* containing millions of red spores *(urediniospores)* appear on the stems of infected grain plants.

When these red spores are blown to other grain plants, they germinate and in from 7 to 10 days new rust pustules appear. This

process may be repeated a number of times. The rate of red spore production and consequent spread of rust on grain depends upon the resistance and maturity of the grain, upon the abundance of susceptible wild grasses, and upon weather conditions.

In Ohio, black rust spores *(teliospores)* replace the red spores in the pustules in June and July. The parasite lies dormant during

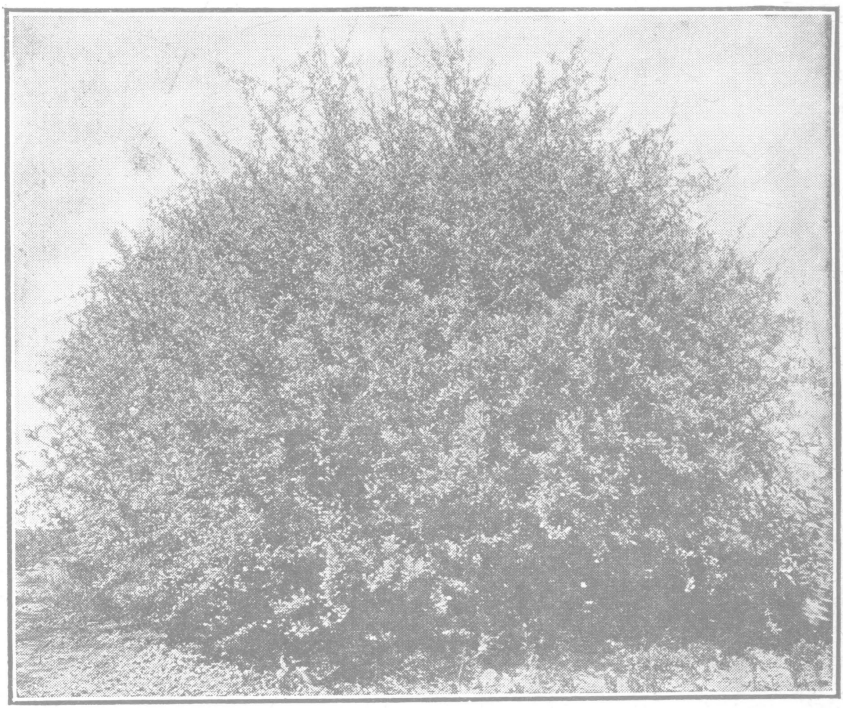

Fig. 3.—A Japanese barberry bush, showing spreading habit of growth.

the winter in the black stage on old straw and stubble. Only black spores can bring about infection of the common barberry. Therefore, if common barberry bushes are eliminated the black spores will become absolutely harmless.

Japanese Barberries Do Not Harbor Rust.—There are many kinds of barberries. The Japanese barberry *(Berberis thunbergii)* does not harbor rust and should not be destroyed. The common green-leaved barberry *(Berberis vulgaris)* and the common purple-leaved barberry *(Berberis vulgaris* var. *purpurea)* harbor rust and should be destroyed. Certain definite characters serve as a means of distinguishing between the harmful and harmless species.

The common barberry, as shown in Figs. 2 and 4, has a tall erect habit of growth and the bark is grayish. Spines, usually

three-branched but sometimes single, are borne along the stems. The green or purple leaves have saw-toothed edges. Yellow flowers and red berries are borne in currant-like clusters. The ripe berries are tart to the taste.

The harmless Japanese barberry, as shown in Figs. 3 and 4, has a low, graceful habit of growth and the bark is reddish brown.

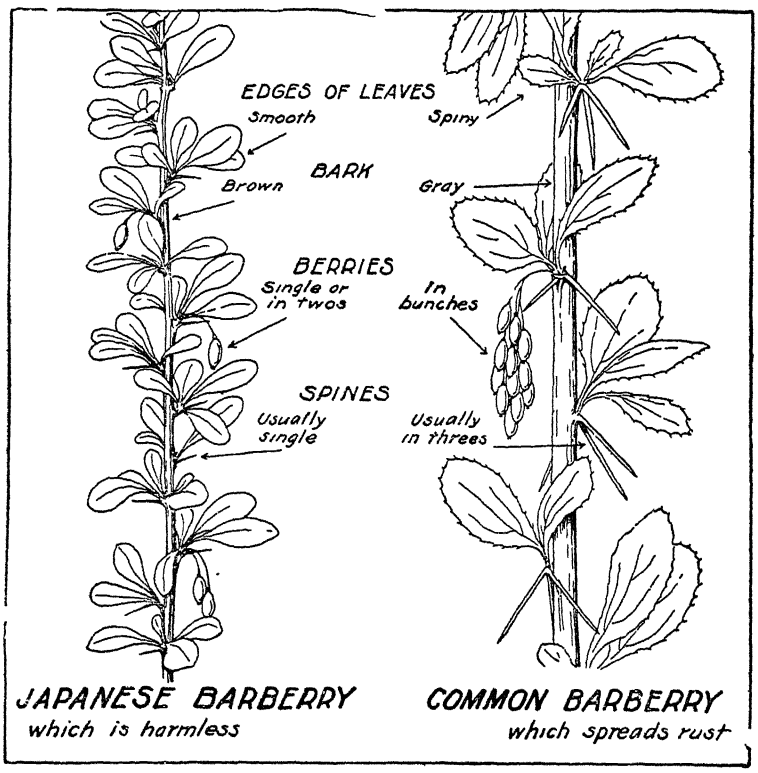

Fig. 4.—Twigs of common and Japanese barberry, showing the characteristic differences.

Spines on the branches are usually borne singly. The margins of the leaves are smooth. The flowers are yellow and the berries are red, but in this case they are borne singly or in pairs. The mature berries are neutral or flat to the taste.

The Barberry Eradication Campaign

Farmers in Europe and America destroyed barberries in efforts to control black stem rust many years before Anton de Bary in 1865 produced scientific proof of the actual relationship between barberries and rust. Barberry eradication has been practiced on a

large scale with remarkable success in Denmark and in England. Results there have shown conclusively that black stem rust can be materially reduced and possibly eliminated by the destruction of common barberries.

Barberry eradication has been practiced in limited areas in various places in the United States for many years. The project was organized on a large scale by the Office of Cereal Investigations of the Bureau of Plant Industry, United States Department of Agriculture, in March, 1918. The demand for increased food production during the late war was largely responsible for starting a systematic campaign simultaneously in 13 north-central grain-producing states, namely, Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming. Cooperation was established with various state agricultural agencies and a survey started in April, 1918.

Progress of the Barberry Eradication Campaign in Ohio.—In 1918 investigations were inaugurated for the purpose of determining the number and distribution of common barberries, the presence of stem rust and the relation between barberries and the occurrence of rust epidemics in Ohio. Many people, including some botanists, doubted whether barberry bushes existed in Ohio in sufficient numbers to exert an appreciable influence on the total rust losses in the state. During the first year, however, sufficient data were obtained to convince the investigators that it was distinctly worth while to eradicate barberries on a large scale in order to control rust losses. Proof was established that common barberries are a tremendously important factor in desseminating black stem rust.

The following year efforts of the workers were confined chiefly to a survey of the larger cities and towns. Almost all towns in Ohio, having a population of three hundred or more, were covered by a house-to-house canvas in search of common barberries.

A systematic farm-to-farm survey was undertaken in 1920 and continued in 1921 and in 1922. Twenty-nine counties in northwestern Ohio were covered by the rural survey up to December 31, 1922. All farms and small towns in this territory were inspected. In addition, in 1922, all barberry locations in 15 of the counties previously covered by the original survey were inspected for sprouts and seedlings.

Field representatives of the United States Department of Agriculture recorded 6,048 barberry plantings containing 230,088 bushes in Ohio up to December 31, 1922. Of these numbers, 5,402 plantings containing 210,438 bushes were removed. In the barberry-eradication states, Ohio ranks eighth in the number of counties completely surveyed but fifth in the number of plantings and fifth in the number of bushes located.

Common barberries have been found in eighty-three Ohio counties (Fig. 5). They have been located in many places, both in town and in the country, in each county covered by the intensive

rural survey. Relatively few grain fields in this area are beyond the possibility of infection by rust from barberries.

In addition to the thousands of barberry bushes grown in ornamental plantings about city and country homes, many other thousands were found growing wild along fence rows and road sides, in woods, thickets, old pastures, and abandoned stone quarries in various parts of the state.

Occurrence of Stem Rust in Ohio.—Common barberries rust generally all over Ohio. In 1922, rust made its appearance on bar-

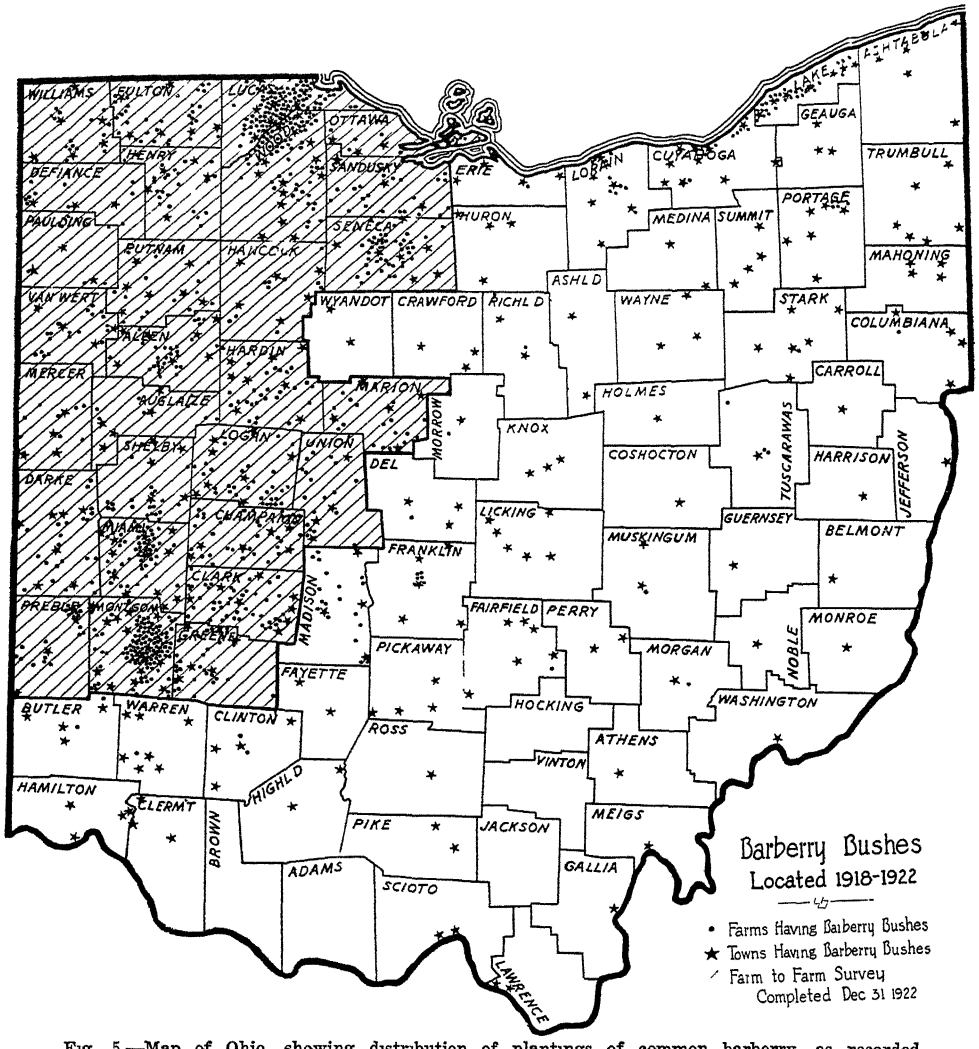

Fig. 5.—Map of Ohio, showing distribution of plantings of common barberry, as recorded December 31, 1922.

berry leaves in the central part of the state about April 10. The date varies with the season and the latitude.

Each year numerous severe local stem rust outbreaks occur on grain in many places thruout the state. The fields may give promise of good yields until shortly before harvest when the effect of the rust becomes more apparent. Thrashing the grain often reveals the fact that the acre yield has been cut to 8 or 10 bushels of lightweight shriveled grain. Other factors, such as hot, dry weather, head scab, leaf rust, and insect depredations may sometimes be responsible in part for low yields, but in many cases there is no doubt that stem rust has played the greater part in causing the damage. Severity and extent of the local epidemics are influenced by maturity of the grain, by weather conditions, and by the prevalence of common barberries in the locality. Wherever severe local outbreaks have been thoroly investigated, it has been possible to trace the source of trouble to infected barberries in the vicinity. A general light sprinkling of stem rust occurs annually in a majority of Ohio wheat fields. This may be caused by spores blown for considerable distances, either directly from barberries or from rusted grain near barberries. It is quite possible that stem rust would continue to occur in this light form even tho all barberry bushes in the state were destroyed. The damage from the scattered light infection, however, is of very minor importance in comparison with losses inflicted by the severe local epidemics.

The Barberry Found Guilty

Origin of Barberries in Ohio.—Common barberries are not native in Ohio. Pioneers brought them from the New England States, cultivated and prized them, not only as ornamentals and hedges, but also as a source of fruit. They were planted in yards and gardens. Birds often feed upon the berries and distribute the seeds to woodlands, thickets, and fence rows, in some instances for miles from the original bushes. Consequently thousands of bushes that have escaped from cultivation have been found growing wild in twenty-three Ohio counties.

Spread of Rust Studied Near Dayton.—In 1922, common barberries were found growing in other shrubbery along the Lebanon Pike, in the eastern edge of Hills and Dales Park, near Dayton, Ohio. A portion of the park had been plowed and sown to wheat the previous autumn. The barberries were within two feet of the eastern edge of the wheat field. These circumstances constituted a favorable situation for the careful study of the relation between barberries and the spread of black stem rust to wheat.

Accordingly, successive observations were made and maps were prepared from the data obtained, illustrating the progressive development of stem rust (Fig. 6). On April 10 rust infection first appeared on the barberries. The cluster cups containing yellow rust spores were first in evidence on April 17. No stem rust was present on the wheat at that time. The first red pustules of the

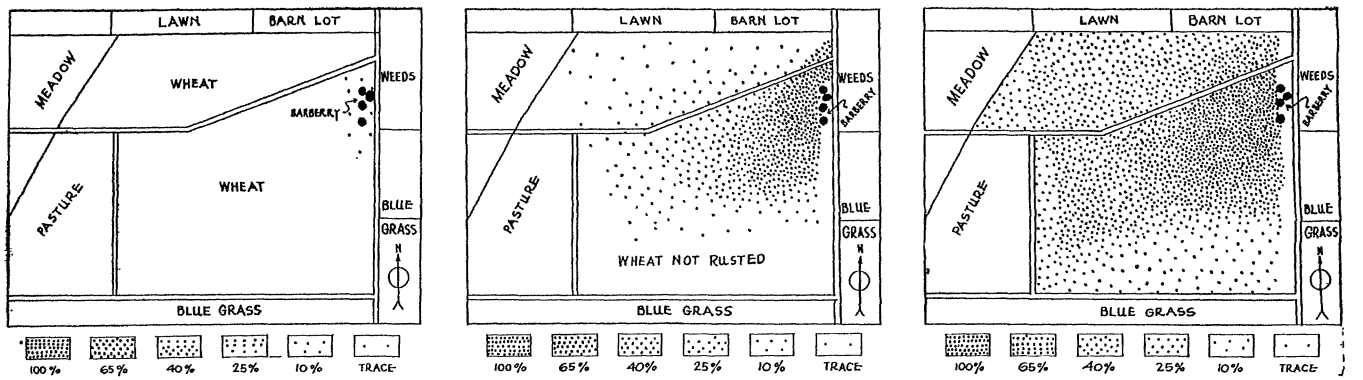

Fig. 6.—Map showing the spread of stem rust from infected barberries to wheat on successive dates during 1922.

stem rust appeared on May 14, but on only a few wheat plants near the infected barberries. On May 26 red pustules of the rust could be found on wheat as far as 30 yards from the barberries. However, the infection was very light on that date. Between May 26 and June 5 the rust spread rapidly in the field. Wheat that showed light rust infection on May 26 was covered with rust by June 5. On the latter date, the disease was prevalent on the wheat in three-fourths of the field but even then there was not a trace of rust on the wheat growing along the south and west edges. By June 16, wheat near the barberries was ruined and the black stage of the parasite had developed. There was no further spread of the disease. The successive stages of rust severity were distinct and it was clearly demonstrated that the rust came from the infected barberries.

Barberries and Rust at West Carrollton.—Mr. James Lowry, a resident of West Carrollton, Montgomery County, Ohio, stated that when he purchased the home in which he now lives, about 60 years ago, a large, old barberry bush was growing in the back yard. At that time the bush was regarded as a prize specimen, since it was the only barberry in the neighborhood. Seeds from this bush were scattered broadcast and as a result hundreds of barberry bushes and thousands of seedlings were found, in 1921, on six farms adjacent to the village. Mr. Lowry declared that severe black stem rust epidemics were unknown in the vicinity until barberries became established in the woods. He also said that local farmers had lost crop after crop of wheat sown near the barberries during the last 30 years.

Mr. Alonzo Michaels owns a farm near the Lowry homestead. In discussing damage from black stem rust he said that he had lost several crops of wheat by rust and that 100 acres of his wheat had been ruined by black stem rust in 1919.

Another farmer who lives near the escaped bushes used 16 bushels of wheat, in the fall of 1921, in seeding 7 acres of ground. Prospects for a bumper crop were excellent until the rust struck it. All of the wheat plants in the field were covered with stem rust and the farmer harvested 61 bushels of shriveled grain that was of value only for poultry feed. Wheat at a distance of 2 miles in all directions from the escaped barberries was slightly damaged by stem rust.

The Lewisburg Situation.—About 50 years ago a common barberry hedge was planted around an orchard about a mile northwest of Lewisburg, in Preble County, Ohio. About 25 years ago someone told the owner of the hedge that if he wished to stop the annual black stem rust attacks on his wheat, destruction of his barberries was absolutely necessary. All attempt was then made to kill the hedge but the rust was not checked. There was a mighty good reason for failure of the remedy. Limestone outcrops are prevalent near the orchard. Barberries thrive on limestone soil. The birds did their part and in 1920 more than 10,000 barberry bushes

were found growing wild on 12 adjacent farms. Farmers living in the vicinity had practically abandoned sowing wheat on account of black stem rust. Local residents related many stories of wheat crops ruined by stem rust. There was a tendency for them to attribute the cause of the rust to the dampness that prevailed in the Twin Creek Valley. However, the dampness occurred along the same creek 10 miles south of Lewisburg but there the rust was not severe.

The Mingo Case.—About 1832 a common barberry bush was planted on a farm now owned by Mr. Fred Connolly, about 2 miles north of Mingo, Logan County, Ohio. The stump of the original bush is still in evidence. Birds scattered the seeds over the surrounding country and, in 1919, thousands of escaped barberry bushes were found on 13 adjacent farms. In one instance a large escaped bush was found almost 2 miles from Mr. Connolly's farm. Old residents of that locality cannot remember a single year when their wheat was not damaged by black stem rust. They thought it strange that wheat grown eight to ten miles away usually was practically free from rust.

Mr. E. O. Thomas, who is a neighbor of Mr. Connolly, in referring to the rust situation in 1922, said, "The damage in dollars to farmers of this locality from black stem rust would be hard to estimate. It probably affected 200 acres the past season and cut the yield to 8 or 10 bushels per acre and a test of from 45 to 52 pounds per bushel. The prospects were for quite a few 20-to-25-bushels-per-acre fields and prospects were good until about a week before cutting time when black stem rust made its appearance and left our wheat fields practically worthless."

Black Stem Rust Controlled on Ohio Farms

Much time and effort was expended recently in attempting to control stem rust in the instances just related. In each case the rust was considerably diminished but not completely checked. It was not possible to get rid of all the barberries at the time. Not all the barberries were found, and attempts to destroy some that were found were unsuccessful. In digging large bushes root fragments were often left in the ground and sprouts were produced. Small seedlings growing among wild rose bushes, weeds, and grass escaped notice. Elimination of escaped barberries in such locations is a slow, tedious process but can be accomplished.

A Putnam County Case.—The experience of John Diller, a Putnam County farmer is one of many which might be described to illustrate the effectiveness of barberry eradication as a means of controlling black stem rust on wheat. Twenty-six years ago Mr. Diller brought common barberries from Kansas and planted them on his farm near Pandora, Ohio. For a number of years thereafter his wheat was severely damaged by black stem rust. In 1919 he was told that his barberries were responsible for the rust outbreak prevalent in the community that season, and he was urged to

eradicate them immediately. The barberries were not destroyed until August, 1921, because Mr. Diller did not believe that the removal of his barberries would stop the rust. In 1922 his wheat escaped injury for the first time in many years. Mr. Diller is now an ardent advocate of barberry eradication. In a recent letter he wrote, "I have no more use for a barberry on my farm than I have for a cow that has not been tuberculin tested."

A County Agent's Experience.—The following extracts from a letter from Mr. Ford S. Prince, Agricultural Agent in Greene County, summarize his observations on black stem rust development and control.

"I am informed by farmers that our experience with black stem rust in Greene County is of long standing, but one of the worst outbreaks of the disease on wheat occurred in 1918. So destructive was the trouble that about 100 acres of wheat were not cut and all of the wheat on the western side of Greene County—where most of our wheat is produced—was more or less infected.

"Yields fell as low as 7 or 8 bushels and weights as low as 45 pounds per bushel during that season. Weights of 50 and 52 pounds per bushel were very common.

"Farmers in close touch with the situation estimated the loss to Greene County farmers from this trouble in 1918 at from $50,000 to $100,000, from wheat not cut, reduced yields, and low weight and quality.

"Near fields which were not harvested in 1918, we found the common barberry of both the purple- and green-leaved varieties. These were taken out at once. On the farm of E. O. Maxwell, living west of Bellbrook, about 20 shrubs were removed. Mr. Maxwell had lost 20 acres of wheat and A. L. Gilbert across the road also had 20 acres of wheat which he did not harvest. These men stated that they had always had some black stem rust. I checked up on the situation on these two farms in June, 1922, and found no traces of black stem rust. The men stated that they had had no damage from the disease since 1918, the year Mr. Maxwell removed the shrubs.

"From July, 1918, we have waged a relentless campaign on the common barberry in Greene County, and have removed or had it removed from all locations save two that we know of. Wherever a severe outbreak of black stem rust has been reported since 1918 we have always found common barberries in the vicinity. During June, 1922, two outbreaks were reported to this office. One was on the farm of R. R. Huston, Sugar Creek Township. On investigation we found two large common barberry bushes near a house on another farm. These shrubs were about 150 feet from the wheat field so badly damaged. Infected leaves were found on the barberries. Mr. Huston stated that he had never believed that barberries caused black stem rust, but that this instance convinced him. We traced the rust both east and west from this field and found that the wheat for about 2 miles either way was damaged but that the further away we went from the shrubs the less damage had been done.

"The other outbreak in 1922 occurred on the farm of John Shane, in Ross Township. A mammoth common barberry specimen was found in the yard of the house occupied by Mr. Shane. Infected leaves were found on the barberry. One field of wheat grown by Mr. Shane was very severely damaged, the yield was 8 bushels per acre and of low quality. The edge of the field was not more than 100 feet from the bush. We traced the spread of this infection about 1½ miles east of Mr. Shane's home and found black stem rust as far as we went, altho at that distance it had done little damage.

"All these situations have convinced me that there is a definite connection between barberries and black stem rust and I am also convinced that in this locality the removal of the common barberry will prevent outbreaks of black stem rust on wheat. To date, we have found no outbreaks of this disease that we could not trace to a bush of this species of plant.

"I am speaking not only for myself but for farmers whose wheat yields had in previous years been damaged by the black stem rust but who have ceased to have trouble in this regard since the war on the barberry was undertaken."

Chemical Eradication

Various methods have been employed in eradicating barberry bushes. The most common method has been digging them out with spade and mattock. In other cases they have been pulled out by horses or tractors and blown out with dynamite or other explosive. Some roots or pieces of roots are very likely to be left in the ground when such methods are used. The roots have a pernicious habit of sprouting, even for several years after the bushes have been dug. In lawns this is not a serious matter, since any sprouts that come up may be readily found and removed. When there are only a few bushes on lawns or other places that may be easily watched, careful digging is perhaps the best method of eradication.

Many difficulties arise, however, in eradicating barberry bushes in wild areas where they frequently occur in very large numbers. Escaped barberries often grow in dense thickets, among weeds, along fence rows, at the bases of trees and stumps, and among limestone rocks, where digging is very difficult and where it is practically impossible to remove all the roots. The need for a more effective method of eradication than digging is quite evident. In the search for such a method, investigators have tested the effects of more than 40 different chemicals on barberry bushes. A number of these chemicals have proved destructive to the bushes, but only two of them are to be recommended for use at this time according to Thompson*, who has been in charge of the experimental work in several states.

Thompson states that 10 pounds of crushed rock salt —ice cream salt is preferable—will kill a bush in which the clump of

* Thompson, Noel F. Kill the common barberry with chemicals. U. S. Dept. Agr. Cir. 268: 1-4. 1923.

stems is approximately 12 inches in diameter at the soil surface. More or less should be applied to larger or smaller bushes, with a minimum of 5 pounds. It should be placed in a pile in the center of the bush. It is advantageous to leave the bushes standing since they can be more readily found when it is desired to determine whether they have been killed or whether they have sprouted.

A commercial sodium arsenite solution has also been found very effective in killing barberries, according to Thompson. For use, each gallon of the commercial product is diluted with 40 or 50 gallons of water. Two gallons of the dilute solution are required to kill a bush whose clump of stems is 12 inches in diameter at the surface of the ground. Larger or smaller bushes should be treated proportionally but 1½ gallons is the minimum amount recommended. The solution is poured over the ground in the center of the clump so as to wet the base of every stem.

Sodium arsenite is poisonous, and should be kept where children and livestock cannot get to it. It should be used in the destruction of barberry bushes only during the growing season, according to Thompson. Common salt is effective in all seasons of the year. Both salt and sodium arsenite will kill all vegetation within a radius of 2 or 3 feet around the spot where it is applied.

Legal Status of Barberry Eradication

A Federal quarantine prohibiting the shipment of rust-susceptible barberries into the states that constitute the barberry eradication area became effective May 1, 1919. Even tho common barberries are listed in many nursery catalogues sent into Ohio they cannot be transported legally into the state. The Ohio Department of Agriculture placed a quarantine, effective December 15, 1919, against the movement of common barberries within the state.

In the matter of compulsory eradication of common barberries, the Secretary of the Ohio Department of Agriculture derives legal authority from Sections 1128-1132, General Code of Ohio. Section 1128 follows:

> "The Secretary of Agriculture thru the inspector and deputies is hereby empowered to investigate outbreaks of dangerous insect or plant diseases occurring within the state and to prescribe and enforce such preventive and remedial measures as he may deem necessary to the control or eradication of such outbreaks, and for such purposes shall have free access to any property or premises within the state."

On November 26, 1920, the Attorney General of Ohio rendered Opinion No. 1662 confirming the sufficiency of the Ohio Plant Pest Law in regard to the compulsory eradication of common barberries.

It is indeed remarkable that, during the past 5 years, it has been necessary to summon the assistance of the Ohio law in only a very few instances. Laws alone will not rid Ohio of harmful barberries. Successful state-wide eradication depends largely on public interest and cooperation.

Summary

Black stem rust occurs practically thruout Ohio, causing severe losses in numerous localities.

One stage of the fungus causing this rust occurs commonly on the leaves of the common barberry early in the spring. Investigation of the severe local epidemics reported during the past few years has revealed in every case the fact that the common barberry played an important part in the inception of such outbreaks. Following eradication of these barberry bushes, grain on the same farms remained practically free from rust in succeeding years.

Stem rust appeared on grain near infected barberry bushes earlier than on grain at a distance from the bushes. The spread of rust from barberry bushes to nearby wheat plants and from these by successive stages to other wheat plants further away has been clearly established by careful study and observation in particular localities.

The writers are confident, in the light of their experience during the last 5 years, that wherever severe local epidemics of black stem rust occur in Ohio, infected common barberry bushes will be found in the vicinity of the diseased grain fields, and that the eradication of these bushes will result in freedom from further severe losses from this rust.

Barberry bushes are growing wild in many communities. The number of such localities will increase if the growing of barberries continues. Bushes in towns, in cities, and in the country may be the source of the bushes growing wild. Eradication of wild bushes is a difficult problem, especially in certain places, largely on account of the tendency of roots that are left in the soil to send up sprouts. The use of rock salt or of a commercial arsenite of soda solution, gives considerable promise of solving this difficulty.

The cost of barberry eradication in Ohio is very low in comparison with the resulting savings. The loss from the local outbreaks of black stem rust in one year far exceeds the total cost of eradication in this state for 20 years. The estimated loss from stem rust in Champaign County in 1922 was nearly twice the total cost of survey and eradication in Ohio for 5 years.